

CLAIMS

1. A multi-layer electronic component comprising;
a stack formed by stacking piezoelectric layers and
5 internal electrodes one on another alternately and,
a pair of external electrodes formed on two opposing
side faces of the stack,

wherein the internal electrode has a first internal
electrode connected to the external electrode formed on one
10 of the two side faces and a second internal electrode located
between the first internal electrode and connected to the
external electrode formed on the other one of the two side
faces, and

wherein the internal electrodes and the piezoelectric
15 layers are faced in proximity so that a space between them is
2 μm or less over an area occupying 50% or more of the active
region where the first internal electrode and the second
internal electrode oppose each other.

20 2. The multi-layer electronic component according to
claim 1,

wherein a change in a degree of orientation of the
crystal grains that constitute the piezoelectric layer is
within 5%.

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3. The multi-layer electronic component according to claim 2,

wherein an average grain size of the crystal grains of the piezoelectric layer is 5 μm or less.

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4. The multi-layer electronic component according to claim 3,

wherein thicknesses of the piezoelectric layers are 200 μm or less.

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5. The multi-layer electronic component according to claim 1,

wherein thicknesses of the internal electrodes are 5 μm or less.

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6. The multi-layer electronic component according to claim 1, the internal electrode including an inorganic component different from the metal which is main component, wherein an average particle size of the inorganic component is smaller than an average grain size of the crystal grains of the piezoelectric layer.

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7. A method of manufacturing the multi-layer electronic component comprising;

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a process of forming a column-like stack by stacking a

plurality of ceramic layers and a plurality of internal electrodes alternately one on another,

a process of trimming the column-like stack to predetermined dimensions,

5 a process of applying heat treatment to the column-like stack,

a process of applying an electrically conductive paste on the side face of the column-like stack,

10 a process of applying heat treatment to the electrically conductive paste and form a pair of external electrodes that are connected to the internal electrode alternately, and

15 a process of applying a voltage to the external electrodes and carrying out polarization treatment so that the change in the ratio of lattice constants c/a becomes 0.5% or less.

8. The method of manufacturing the multi-layer electronic component according to claim 7;

20 wherein a rate of cooling down from the maximum temperature of heat treatment is set to $t/3$ ($^{\circ}\text{C}/\text{minute}$) or less in the process of applying heat treatment to the electrically conductive paste, where t ($^{\circ}\text{C}$) is Curie temperature of the ceramic layer.

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9. The method of manufacturing the multi-layer electronic component according to claim 7;

wherein a rate of cooling down in a temperature range from 1.2t to 0.8t in the heat treatment is set to t/3 (°C/minute) or less in the process of applying heat treatment to the electrically conductive paste, where t (°C) is Curie temperature of the ceramic layer.

10. A multi-layer piezoelectric element comprising a stack formed by stacking piezoelectric layers and internal electrodes one on another alternately, wherein an average crystal grain size of a portion of the piezoelectric material that makes contact with the internal electrode is larger than an average crystal grain size of the other portion.

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11. A multi-layer piezoelectric element comprising a stack formed by stacking piezoelectric layers and internal electrodes one on another alternately, wherein a minimum crystal grain size of a portion of the piezoelectric material that makes contact with the internal electrode is larger than a minimum crystal grain size of other portion.

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12. The multi-layer piezoelectric element according to claim 10;

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wherein a minimum crystal grain size of the portion

that makes contact with the internal electrode is 0.5 μm or more and 5 μm or less.

13. The multi-layer piezoelectric element according
5 to claim 10;

wherein the internal electrode includes group VIII metal and/or group Ib metal as a main component.

14. The multi-layer piezoelectric element according
10 to claim 13; the internal electrode including
a group VIII metal and/or a group Ib metal as a main component, wherein proportion M1 (% by weight) of group VIII metal and proportion M2 of group Ib metal are set the relations of $0 < M1 \leq 15$, $85 \leq M2 < 100$ and $M1 + M2 = 100$.

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15. The multi-layer piezoelectric element according
to claim 14;

wherein the group VIII metal is at least one kind
selected from the group consisting of Ni, Pt, Pd, Rh, Ir, Ru
20 and Os, and Ib metal is at least one kind selected from the
group consisting of Cu, Ag and Au.

16. The multi-layer piezoelectric element according
to claim 15;

25 wherein the group VIII metal is at least one kind

selected from the group consisting of Pt and Pd, and Ib metal is at least one kind selected from the group consisting of Ag and Au.

5 17. The multi-layer piezoelectric element according to claim 15;

 wherein the group VIII metal is Ni.

10 18. The multi-layer piezoelectric element according to claim 15;

 wherein the group Ib metal is Cu.

 19. The multi-layer piezoelectric element according to claim 13,

15 wherein the internal electrode includes an inorganic component different from the metal which is main component.

 20. The multi-layer piezoelectric element according to claim 19,

20 wherein the inorganic component includes a perovskite type oxide constituted from PbZrO_3 - PbTiO_3 as a main component.

 21. The multi-layer piezoelectric element according to claim 10,

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wherein the piezoelectric layer includes a perovskite type oxide as a main component.

5 22. The multi-layer piezoelectric element according to claim 21,

wherein the piezoelectric layer includes a perovskite type oxide constituted from PbZrO_3 - PbTiO_3 as a main component.

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23. The multi-layer piezoelectric element according to claim 10,

wherein the stack is fired at a temperature of 900°C or more and 1000°C or less.

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24. The multi-layer piezoelectric element according to claim 10,

wherein a change in the composition of the internal electrode before and after firing is 5% or less.

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25. The multi-layer piezoelectric element according to claim 10, the internal electrodes including first internal electrodes and second internal electrodes stacked one on another alternately, end portions of the first internal
25 electrodes being exposed on the first side face of the stack

while end portions of the second internal electrodes being located apart from the first side face, the end portions of the second internal electrodes being exposed on the second side face of the stack while the end portions of the first
5 internal electrodes being located apart from the second side face,

wherein the first side face has grooves formed toward the end portions of the second electrodes and the second side face has grooves formed toward the end portions of the first
10 electrodes, the grooves being filled with a dielectric material of which Young's modulus is lower than that of the piezoelectric material.